

The 1821 Zacatecas Eight Reale Non-Homogenous Surface Puzzle – Cleaned or the Result of an Improper Mercury Amalgamation Manufacturing Process?

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Background

When Robert Gurney came out with his groundbreaking book on Counterfeit Portrait Eight Reales this author decided to fly down to the MNA (Second Annual - Mexican Numismatic Association Conference) in Arizona to meet him in person and help promote the book with fellow MNA members attending this Conference. Making a long story short - this fellow comes up and compliments the GNL Eight Reale book but then said "How about the 1821 Zacatecas Eight Reale issues - What is going on with the surfaces of this issue? I thought Bob Gurney and yourself would address this particular issue? Are some of these counterfeits due to their STRANGE surface appearance?" At that point I had to admit I did not know much of these issues but did agree with him after investigating this a bit further on returning home indeed in upper grades (AU & better) some Eight Reale examples (not all but approximately a third in grades of AU or higher from my observations) had these non-homogeneous silvery/white-darkish band surfaces as to make them appear cleaned since the surfaces were anything but uniform and homogenous. See this example that I purchased from a recent Stacks/Bowers auction which is a very good example of my point here with these 1821 Eight Reales Zacatecas issues and their non-homogeneous looking surfaces.

The coin in question with excellent photos came from the Stacks/Bowers June 2019 Collectors Auction of World Coins and was lot 71770 in this sale. The coin currently is in the author's collection and the coin analyzed in this paper. See also Figures 6 and 7 below.

Web-link at the Stacks/Bowers Numismatic Auction Archives from their Home Page of the coin in question: <https://auctions.stacksbowers.com/lots/view/3-IW22N/mexico-war-of-independence-8-reales-1821-zs-rg-zacatecas-mint-ferdinand-vii-ngc-au-details-obverse-improperly-cleaned>

If we look under a stereo microscope under varying 20-40X power magnifications we see in certain letters deep in their devices also salt crystal build-up which I believe due to their semi-opaque slight yellowish appearance to be AgCl deposits. Notice also the white/darkish bands throughout in the fields and devices for both the obverse and reverse. The white bands can be considered the normal silver looking areas and the darker bands may be the result of silver sulfide accumulations which I believe came from an improper mercury amalgamation process and not from typical atmospheric sulfur contamination or post mint cleaning. There are no signs of dipping or polishing surface marks just regular stray normal circulation marks under a stereo microscopic review (i.e., no circular hairlines just intermittent contact marks in a haphazard fashion and not of a degree suggesting it was polished in any manner). The coin also has full mint luster with a full unbroken cartwheel effect indicating the surfaces are totally original. The coin is UNC in my opinion showing no wear but probably reduced to AU in the belief the coin was improperly cleaned which is usually the case in dropping coins a grade level or so if cleaned with these Third Party Grading (TPG) grading companies such as ANACS, NGC or PCGS. To a third-party grading outfit and to most people a non-uniform surface obviously means it's been cleaned or tampered with after it left the Mint. Performing SEM/EDS analysis will allow me to identify the *compounds* on the surface and possibly the core if required (i.e., the author would cut this coin in half and do a core to surface check if necessary if the compounds detected on the surface from his experience prove inconclusive). XRF would only yield the individual elemental metal percentages and as some of you already know sulfur (S) and Chlorine (Cl) are the two most common outside contaminants on the surface of *any* coin which then promotes their

toning - particularly sulfur with the copper in this alloy as one example (i.e., the more oxidative element (copper) will tone more when comparing copper to silver). Sulfur toning with copper from my experience was not at work for this example due to its high grade and non-uniformity on the surfaces (i.e., if cleaned we would see more brush marks under magnification or a uniform toned coin). If we read about the Hacienda Mints using mercury amalgamation and smelting *together* the darker ores called negro or negrilla type ores which had high sulfur and the preferred process was then smelting (i.e., roasting with salt in furnaces) as mercury amalgamation did not work well on these ore types but just ores with high AgCL (i.e., silver halide) type ores or free silver (1). This being 1821 the year of Mexico's Independence and due possibly to a lack of copper sulfate, iron, salt (NaCl) and/or the possible mixing of both dark and light ores and then only using mercury amalgamation and not heat treating the darker sulfur ores with salt (NaCl) would have created these non-homogenous surface white/dark surface effects in my opinion. It was critical to *first treat* these negroes or negrilla ores with salt in a furnace to yield AgCl from AgS as confirmed in Quintero (1) prior to mercury amalgamation. So, my initial theory and by checking most 1821 Zacatecas 8R issues for sale every week such as on EBAY in grades of AU or MS - ask these questions: Why do most have these irregular light/dark banded areas? Under a 10X-15X coin loop review what are these crystals and powdered areas present in the protected area of the coin's devices? It's my belief initially prior to SEM/EDS analysis the light areas may contain some non-reacted AgCl areas and the darker areas some non-reacted AgS areas? As hard as it may be for some to grasp right now the author is proposing prior to the SEM/EDS analysis this NGC label should read "MS63 An Incomplete (i.e. or Improper) Mercury Amalgamated Surface". It would be very simple to prove using metallographic and SEM/EDS techniques to confirm the coin has high areas of AgCl, AgS and Hg₂CL₂ (mercurous chloride or known as calomel) which is a confirmed intermediate in the amalgamation process prior to the silver cake final treatment process where most of the mercury is distilled off by carefully heating these silver cakes (1) and then distilling off the costly mercury to be reused in the next production process. So to answer now the previous mentioned MNA # 2 Conference MNA member inquiry - Yes I believe these issues have been *incorrectly* classified as being *cleaned* and this discoloration has simply to do with poor mercury amalgamation of high sulfide ores or having a lack of certain materials like iron, salt and copper sulfate to assist in their mercury amalgamation process due to these difficult times in Mexico's history (i.e., 1821) where certain raw materials may have been lacking, in short supply or their quality may have been inferior. I do not believe these are later counterfeits in any way. Quintero (1) has indicated at the Zacatecas Mint during this time period approximately 80% of all ores were mercury amalgamated and the remaining 20% by other methods either by AgS furnace roasting with salt (NaCl) as previously mentioned above prior to mercury amalgamation or by lead reduction/oxidation in the furnaces for the occasionally found argentiferous galena (PbS) ores which occasionally were processed which contained silver in their ore. This argentiferous galena type ores were more omnipresent to the types of silver refining practiced in Europe at this time for this ore was more common in Europe than in Mexico which has predominantly AgS & AgCL type ores. This argentiferous galena silver process produced slag and litharge as waste products in its production. Lead simply interfered with mercury in its amalgamation process so only furnace treatment was an economical solution if these ores were processed.

To assist the reader even further let's review the principal reactions in the Zacatecas Patio Mercury Amalgamation Process as illustrated from Quintero's (1) paper to give the reader a better understanding of how these surfaces on this subject coin may have been created with this non-homogenous appearance:

1. Mercury only amalgamates elemental silver. It does not amalgamate silver compounds. This is the fundamental but often overlooked tenet of amalgamation with mercury. In the strict use of the term, amalgamation does not involve a chemical transformation of either mercury or of elemental silver. An amalgam does not have a fixed amount of mercury. It is a physical mixture that does not change the

original chemical nature of its constituents. It can be either a liquid or a solid depending on the amount of excess mercury that it can retain like a sponge retains water.

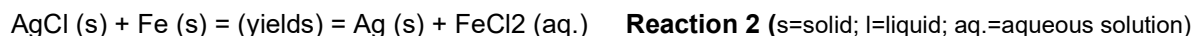
The confusion arises when amalgamation is the term applied to the whole refining process using mercury, during which chemical reactions involving mercury takes place.

2. Mercury reduces silver chloride to silver, and in turn oxidizes to form calomel, mercurous chloride (Hg_2Cl_2). This is the chemical reaction that allowed the first miners of weathered silver deposits in the New World to extract silver using the simple amalgamation recipe derived from the refining of gold. Mercury plays a double role in the amalgamation of silver ores: it is an amalgamating agent, and it is also an active chemical reagent that reduces any silver chloride it comes into contact with according to the following equation:



This is important to understand for the surface of this coin. If for example there was a lack of salt (NaCl) or good quality salt the darker negro ores (i.e., also known as negrillo ores) may have been insufficiently roasted properly to AgCl and hence creating a “darker silver mix.” Mercury amalgamation only works well with AgCl type ores (i.e., silver halide ores) as clearly demonstrated in Quintero’s paper (1 & 2). For this reason darker ores (i.e., AgS ores) were sufficiently treated with salt and roasted in furnaces and then the “newly” transformed ore became a halide ore (i.e., AgCl) which was then ready for mercury amalgamation. See item #4 below.

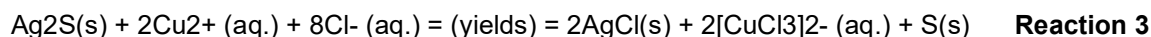
3. Iron and copper can also reduce silver chloride to silver. Iron and copper can also act as reducing agents with silver chloride, as for the example with iron:



These Hacienda Mint workers realized the addition of iron (Reaction 2) or copper for that matter as copper sulfate (pyrites) did assist in this amalgamation and benefited the reaction by requiring less mercury consumption as shown in Reaction 1. Although iron is not usually added to silver coins in most silver alloys it’s considered a surface contaminant or impurity sometimes coming from minting tools and equipment (5) but not in this case based on Reaction 2.

4. Mercury does not reduce silver sulphide to silver. Laboratory runs carried out with mercury, salt and silver sulphides have failed to yield an amalgam of silver and mercury under conditions that replicate the amalgamation process of silver ores (Reaction 1). For this reason these ores require prior treatment in a furnace (roasting) in and around 1000°C with charcoal to reduce AgS ores to AgCl ores which are then ready for mercury amalgamation. See Reaction 3.

5. Silver sulphide reacts with copper salts and sodium chloride (Cl^-) in the presence of oxygen to form silver chloride. Silver sulphide reacts with cupric ions in saline solution to produce silver chloride:



(s=solid; l=liquid; aq. =aqueous solution)

6. Heating a silver sulphide ore with salt will transform the silver sulphide into silver chloride. This is an alternative route to convert silver sulphides into silver chlorides prior to amalgamation with mercury. It is known by the term ‘roasting’ and was used intermittently in the New World.

7. Lead renders a silver ore unfit for amalgamation. Lead amalgamates with mercury, and would be present in much larger quantities than silver in the galena ore. This competition between a much larger content of lead than silver for the same amount of mercury being added would lead to a serious depletion in the amount of mercury available to either amalgamate any silver or to reduce the silver chloride, leading to a very low extraction rate and efficiency of the process. Other metals such as copper and bismuth can also interfere with this process.

In summary from above, silver ores without lead respond to amalgamation by three parallel routes:

- By the direct amalgamation of any native silver with mercury. (Conclusion 1)
- By the reduction of silver chlorides with mercury, iron and/or copper to elemental silver, which then amalgamates with mercury. (Conclusion 2)
- By the formation of silver chloride from silver sulphide in the presence of copper (i.e., source - copper sulfate or copper pyrites) and chloride (i.e., source: NaCl) ions in aqueous solution, which then reacts as in (Conclusion 2) above. As previously mentioned, silver chloride can also be generated from the silver sulphide ores by roasting the ore with salt (NaCl) prior to amalgamation. The only scenarios where calomel is not formed is when native silver is being amalgamated, in which case consumption of mercury could drop to zero. If silver chloride is also reduced to silver by copper or iron, then the consumption of mercury during amalgamation will also be lower. It should be noted the most difficult material to get was salt (NaCl). Zacatecas was in central Mexico away from any coastal salt sources and during 1821 this commodity may have been an issue. It has been noted by Quintero (1) that the closest source of salt to Zacatecas was the town Penon Blanco in the Mexico State of Durango approximately 100 miles away! Some calculations show by mule train this would take 1-2 weeks (3). In my opinion this may have been a primary route cause in possibly creating this improper silver alloy laden with high sulfur. (Conclusion 3)

S. Quintero (2) has also estimated through another cited reference from Guerrero (4) that 67% of the ore was mercury amalgamated at Zacatecas and approximately 33% by smelting somewhat like his projected 80/20 percentage from other sources. Specifically - For the details on the method applied to reconstruct the production levels of silver according to refining method for each Caja of New Spain see Guerrero, *Refining of Silver Ores* (4). It should also be realized the production data only constitutes a baseline case, due to the unknown level of contraband of refined silver over the official record of taxes on silver.

The reader should also be aware that if high sulfide readings are found on the surface of a near Uncirculated coin for this specimen and dispersed in a non-homogenous matter its an interesting surface effect that probably was inherent in the manufacturing process. As Oorlic (5) points out in his paper in his analysis of Serbian coins from the medieval period sulfur can not be from sulfide ore (i.e., such as in his case argentiferous galena (PbS) due to the fact that during the cupellation process the temperature of the silver melt is 900-950°C and a stream of air is conducted over the melt. Under such conditions sulfur cannot remain in a reduced form and is fully removed from the melt, in the oxidized form, as SO₂ gas. But it is known that silver metal has the affinity to react with sulfur or oxygen to form black silver sulfide or silver oxide on the surface. However, the author is pointing out here that this is *not* the reduction/oxidation of sulfur ores as practiced in Europe but this is Mexico where the furnace reduction to AgCl with NaCl being added sometimes was not always to completion and these AgS ores are then at times mixed with silver halide (AgCl) ores and then mercury amalgamated. So, this process is different where high levels of sulfur are retained on the coin's surface and are therefore ore/manufactured related and not from a contamination source (i.e., atmospheric pollution over a long period of time).

Other than coins subjected to underwater corrosion and silver surface enrichment of silver most coins from this period will show their silver and copper combined values equaling ~99% or slightly greater (6) for regal issues such as this legitimate Zacatecas 1821 issue eight-reale. This will also be looked at in the SEM/EDS results particularly for sulfur levels on a near UNCIRCULATED coin or in my opinion UNCIRCULATED coin. Sulfur levels greater than 1% from my experience are quite unexpected but not impossible since the coin really has not the typical black uniform surface of a silver sulfide surface one would expect on a more worn coin or circulated coin (i.e., grades in Good – Extremely Fine).

Laboratory Analysis by SEM/EDS

Energy Dispersive X-Ray Spectroscopy (EDS or EDX) is a chemical microanalysis technique used in conjunction with scanning electron microscopy (SEM). The EDS technique detects x-rays emitted from the sample during bombardment by an electron beam to characterize the elemental composition of the analyzed volume. Features or phases as small as 1 μm or less can be analyzed.

When the sample is bombarded by the SEM's electron beam, electrons are ejected from the atoms comprising the sample's surface. The resulting electron vacancies are filled by electrons from a higher state, and an x-ray is emitted to balance the energy difference between the two electrons' states. The x-ray energy is characteristic of the element from which it was emitted.

The EDS x-ray detector measures the relative abundance of emitted x-rays versus their energy. The detector is typically a lithium-drifted silicon, solid-state device. When an incident x-ray strikes the detector, it creates a charge pulse that is proportional to the energy of the x-ray. The charge pulse is converted to a voltage pulse (which remains proportional to the x-ray energy) by a charge-sensitive preamplifier. The signal is then sent to a multichannel analyzer where the pulses are sorted by voltage. The energy, as determined from the voltage measurement, for each incident x-ray is sent to a computer for display and further data evaluation. The spectrum of x-ray energy versus counts is evaluated to determine the elemental composition of the sampled volume.

This method was chosen by the author as XRF surface analysis would yield only quantitative percentages of individual metallic elements which would have less value here than actual compounds being quantitatively reported. These compounds *possibly* being as unreactive or incomplete end product intermediates from the mercury amalgamation process such as AgCl, AgS, Mercurous Chloride (Hg_2Cl_2), Mercury type amalgams, copper and/or iron intermediaries. The laboratory was instructed to examine all areas – light and dark and also examine the strange crystalline growth seen in these issues protected and present in some hidden letter devices on both the obverse and reverse. Some examples even show crystal film formations as seen in the Eric P. Newman example which this author owns in Mint State MS64/NGC. This coin however having the same light/dark patterns and much larger amounts of crystalline growth was not considered clean by NGC. The laboratory chosen to surface analyze this Stack's coin was Metallurgical Engineering Services, Inc. of Richardson, Texas.

SEM/EDS Results

Paul T. Craddock (7) wrote the chlorides and sulfides of silver are easily reduced back to the metal with a mix of charcoal and a low temperature furnace and crucible. However, Craddock says these ores are rare and most silver was obtained by cupellation. Cupellation is a refining process in metallurgy where ores or alloyed metals are treated under very high temperatures and have controlled operations to separate noble metals, like gold and silver, from base metals, like lead, copper, zinc, arsenic, antimony, or bismuth, present in the ore. The elements which accompany the silver as a result of cupellation seen by Scott (8) in numerous XRF analyses are typically gold (1-3%), lead (0.5-2%), bismuth (~0.2%) and a little iron. These elements can be determined by non-destructive XRF analyses a useful tool for silver analyses as a result especially in preliminary screening before more detailed analyses. Craddock in his book was talking more about European silver ores and the use of lead cupellation processes and Scott also was talking of the trace constituents of European Silver ores and the common trace constituents of Au, Pb, Bi and Fe. In this case with silver halide ores the trace elements are expected to be different somewhat with mercury amalgamation and the reactions previously described by Qunitero (1) in this paper specifically Reactions 1-3 above in the Background section. However, for the silver sulfide ores Qunitero and Craddock agree that silver sulfide ores are treated with charcoal and in a furnace type operation to reduce the silver sulfide ore to silver chloride to allow it to be mercury amalgamated properly (i.e., Reaction 3 and Statement 6).

Another factor prior to reviewing the results of the SEM/EDS results as Scott (8) points out is that it is always preferable to anneal silver alloys in a non-oxidizing environment to prevent excessive oxidation of the copper content. When silver alloys are annealed in the open air, copper oxides tend to form. This is because oxygen is rather soluble in hot silver. The copper layer which forms is tenorite, CuO , which is

black overlying a layer of cuprite, Cu₂O, which is red, and which may penetrate the surface. The black oxide can be removed by pickling in acidic plant juices or mineral acids. Repeating these actions will tend to result in surface enrichment of silver at the surface of the artefact, and in many ancient silver alloys, surface enrichment in silver may easily have occurred as a result of the surface oxidation of copper. This form of reaction or occurrence is mentioned for completeness as we proceed into the SEM/EDS results of this subject coin. Initially, the author does not expect a sophisticated silver producing operation to have this result present in this type of operation in the early 19th Century in Mexico.

The first area examined on the coin was the crystalline growth seen in some of the letter devices. A typical area was the letter H in HISPAN. The crystalline growth after removing the lighter organics (carbon, oxygen, magnesium and aluminum) was silver, chlorine, iron, sulfur and copper. This may be due to silver embrittlement forming these AgCl particles which look pale yellow under a coin loop.

EDAX APEX

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Sample Name: Crystal Growth in H of HISPAN

Semi-transparent material at H of HISPAN

Smart Quant Results

Element	Weight %	Atomic %	Error %
C K	87.19	91.58	3.2
O K	9.63	7.59	13.32
MgK	0.3	0.16	9.09
AlK	0.22	0.1	8.54
SiK	0.2	0.09	9.47
S K	0.12	0.05	15.4
ClK	0.2	0.07	11.68
AgL	1.06	0.12	9.08
CaK	0.11	0.04	32.29
FeK	0.16	0.04	30.74
CuK	0.81	0.16	14.99

kV: 15

Mag: 200

Takeoff: 36.7

Live Time(s): 100

Amp Time(μs): 3.84

Resolution:(eV)
130.5

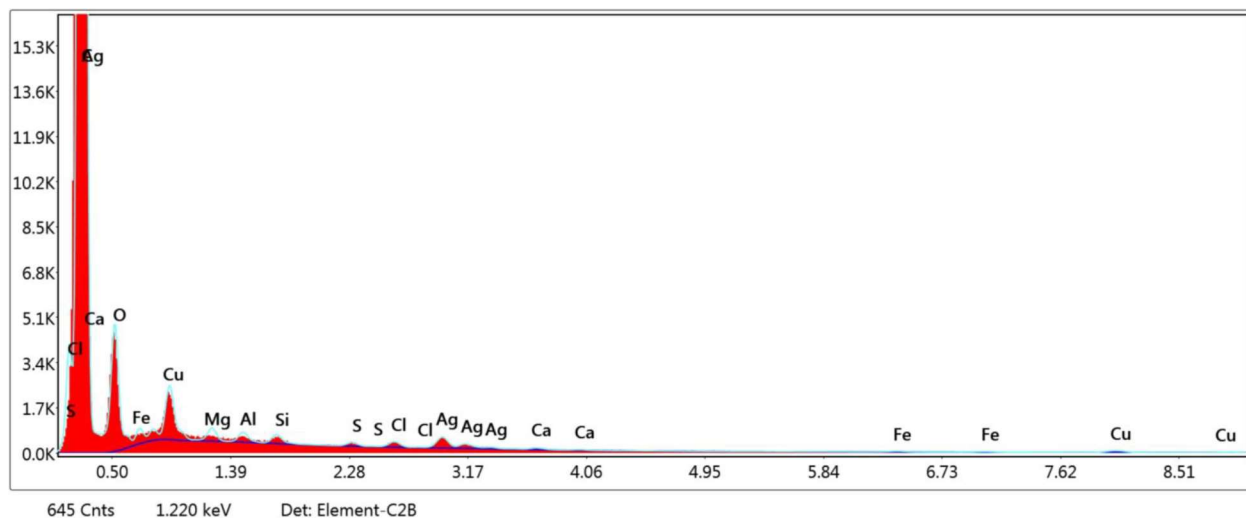


Figure 1: SEM/EDS Analysis of yellowish crystals in and around H of HISPAN. SEM/EDS analysis shows silver, chlorine iron and copper formation probably from the embrittlement of silver on the coin's surface.

The next analysis was the silver area of the coin's surface from the obverse. The SEM/EDS scan is seen in Figure 2, the results below and the micrograph in Figure 3. Silver, copper and abnormally high sulfur seen in the analysis.

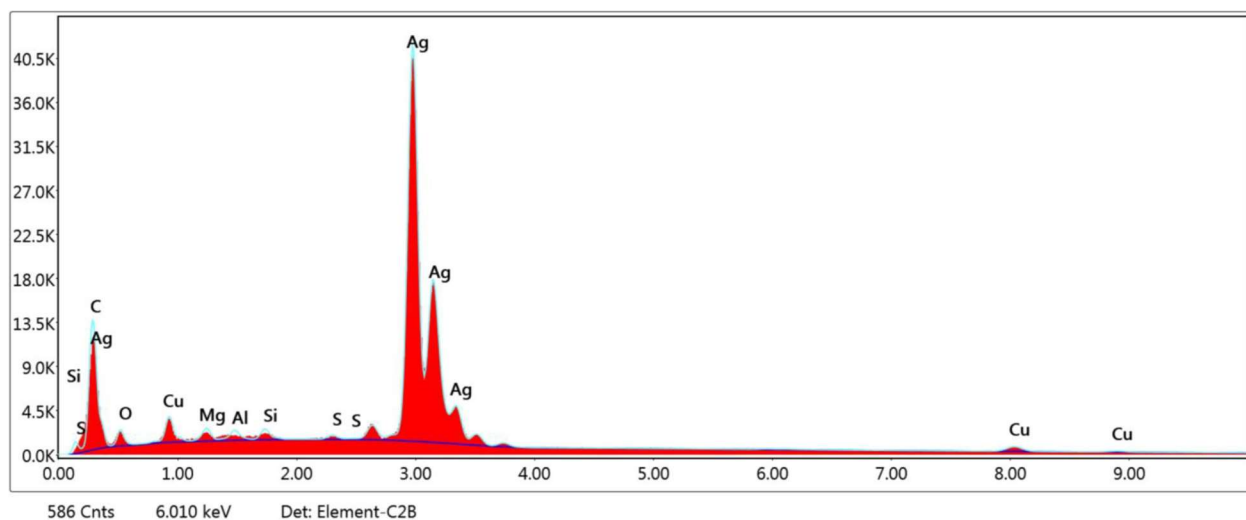


Figure 2: SEM/EDS of the silvery or non-black area of the coin's obverse.

And the results reported below. After again removing the organics (C, O, Mg, Al and Si) which are probable airborne or outside contaminants not relating to its manufacture and quantifying & extrapolating to 100% the silver, copper and sulfur: Ag (94.7%), Cu (4.94%) and S (0.33%). Even the non-black areas are showing an above average sulfur content. Note the lack of chlorides or chlorine in this reading.

Smart Quant Results

Element	Weight %	Atomic %	Error %
37452 Coin Silver area below GR of GRATIA Selected Area 1			
C K	5.52	28.55	6
O K	3.39	13.16	12.09
MgK	0.72	1.83	12.27
AlK	0.68	1.56	10.29
SiK	0.67	1.49	8.54
S K	0.3	0.59	12.23
AgL	84.26	48.48	1.73
CuK	4.44	4.34	8.74
kV: 15			

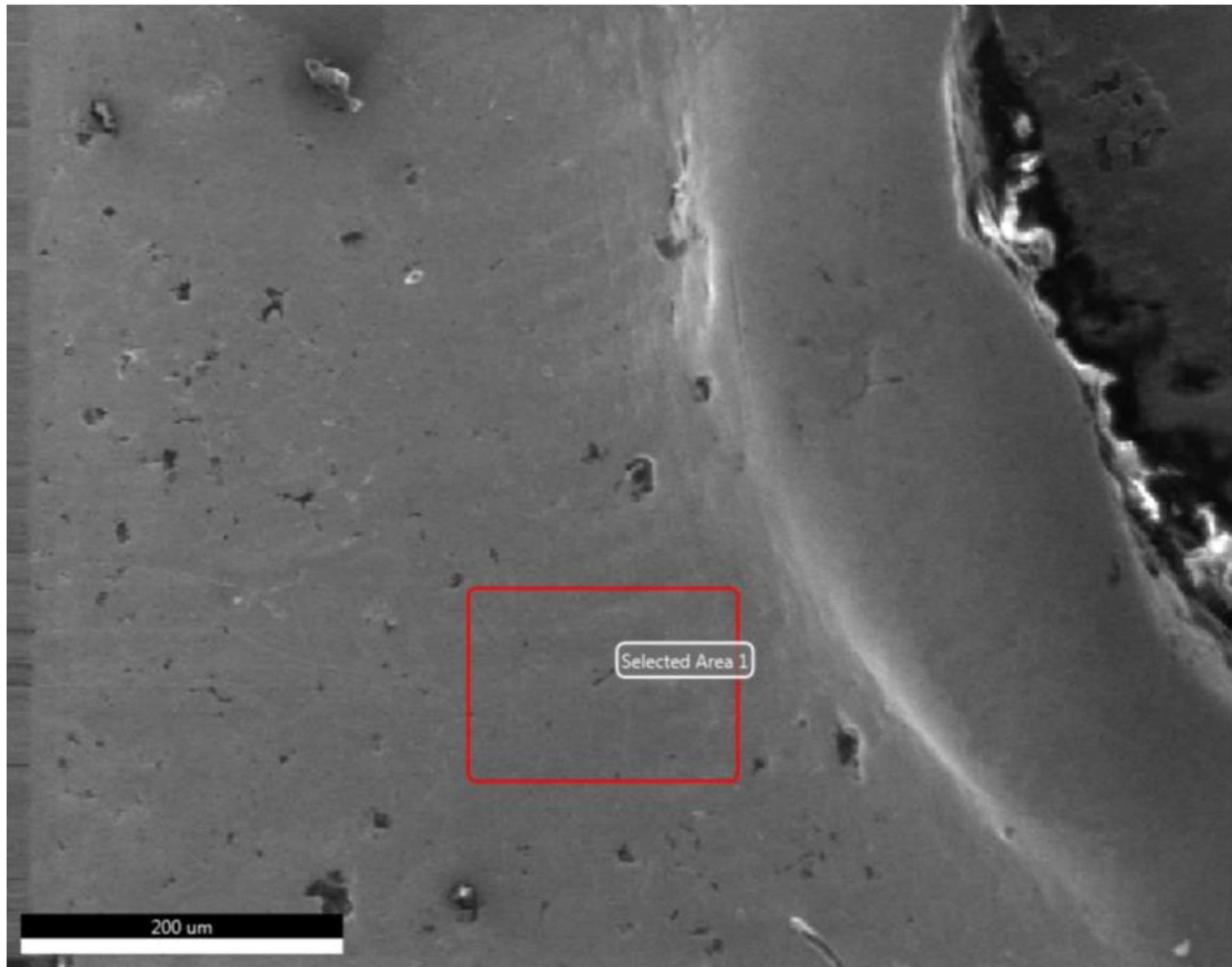


Figure 3: Selected area of a non-dark area below G of GRATIA for SEM/EDS Analysis showing elevated levels of silver probably due to some silver surface enrichment and high sulfur levels normally not seen in AU or UNC specimens. Scale at lower left showing 200μm.

The next area of analysis and the key reason for doing this analysis was to analyze and understand what was making these large black areas of the coin's surface being mis-interpreted as improper cleaning due to the non-homogenous surface of the coin's surface. The results when the author first looked at them in one word was *astounding!* These dark areas are of a high copper content with high sulfur and low silver. The explanation of the dark areas is simple enough as both CuS and AgS are darkish compounds and note the sulfur levels in these dark areas almost being $1.5/0.3 = \text{five times}$ the sulfur levels in the silvery or lighter colored areas previously seen in the Figure 2 results. Its been shown for example in sea salvage reales specimens where silver purity sometimes reaches 98-99% as all the copper leaches out. For some reason a good proportion of the Zacatecas 1821 8 Reales show these high copper sulfur deposits on the surface and in this case, this has nothing to do with copper leaching from the alloy due to salt water corrosion effects. If we look at Reaction 2 above in which instead of iron or the lack of iron copper was added to aid in the transformation of AgCl to free Ag to aid in the mercury amalgamation reaction and this silver had higher levels of sulfur than what is normally desired this may explain these *pockets* of high copper sulfide on the surface of this coin. See the analysis below:

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Sample Name:
Black area between G of GRATIA and the nose
Smart Quant Results

Coin

Element	Weight %	Atomic %	Error %
C K	14.87	38.67	9.19
N K	1.44	3.21	12.58
O K	12.32	24.06	8.86
MgK	0.09	0.12	72.17
AlK	0.32	0.37	16.31
SiK	0.42	0.47	13.19
S K	1.55	1.51	6.37
ClK	0.85	0.75	9.21
AgL	13.08	3.79	2.69
CuK	55.05	27.06	3.41
kV: 15	Mag: 200	Takeoff: 36.7	Live Time(s): 100
			Amp Time(μs): 3.84
			Resolution:(eV) 130.5

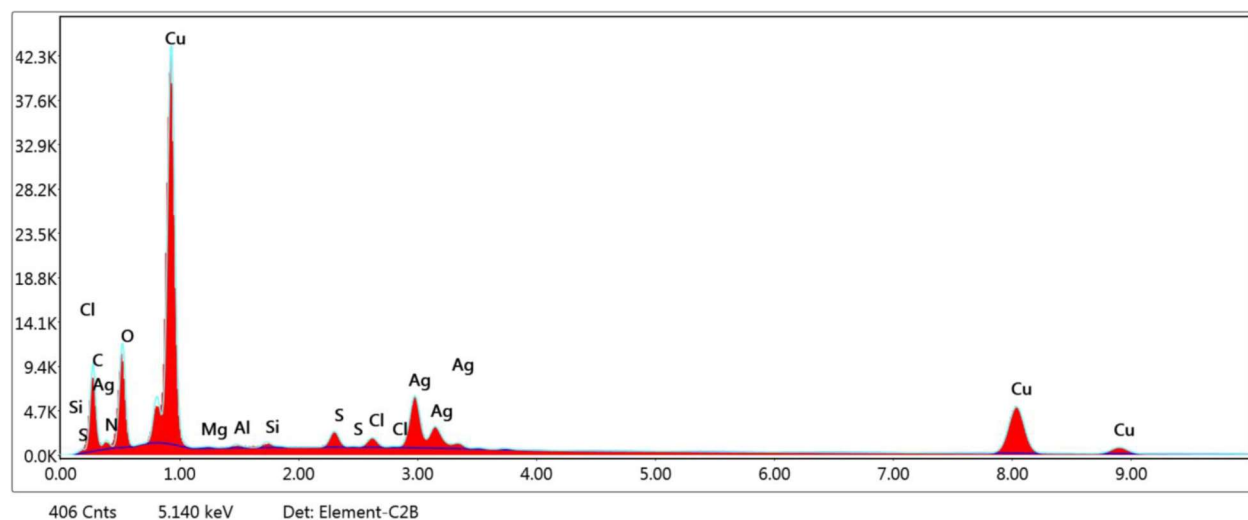


Figure 4: SEM/EDS Analysis of a typical darker area between G of GRATIA and the nose of the portrait. Note the high sulfur and copper and low level of silver.

In Figure 4 above note the elevated levels of copper to silver and the high sulfur. Again extrapolating out the organics and quantifying the four major elements inherent in the alloy in this case: Ag, Cl, S and Cu we get extrapolating to 100% and removing C, N, O, Mg, Al and Si we get: Ag (18.2%), Cu (76.96%), Cl (1.18%) and S (2.17%). This of course for a near Uncirculated or Uncirculated reale in any period to have surface sulfur readings of an extrapolated value of 2.17% is unprecedented. Figure 5 below shows the micrograph taken of a typical black area of the coin's surface in this micrograph - it was a black area between G of GRATIA and the nose of the portrait of Ferdinand VII.

Black area between G of GRATIA and the
nose of the obverse portrait of Ferdinand VII.

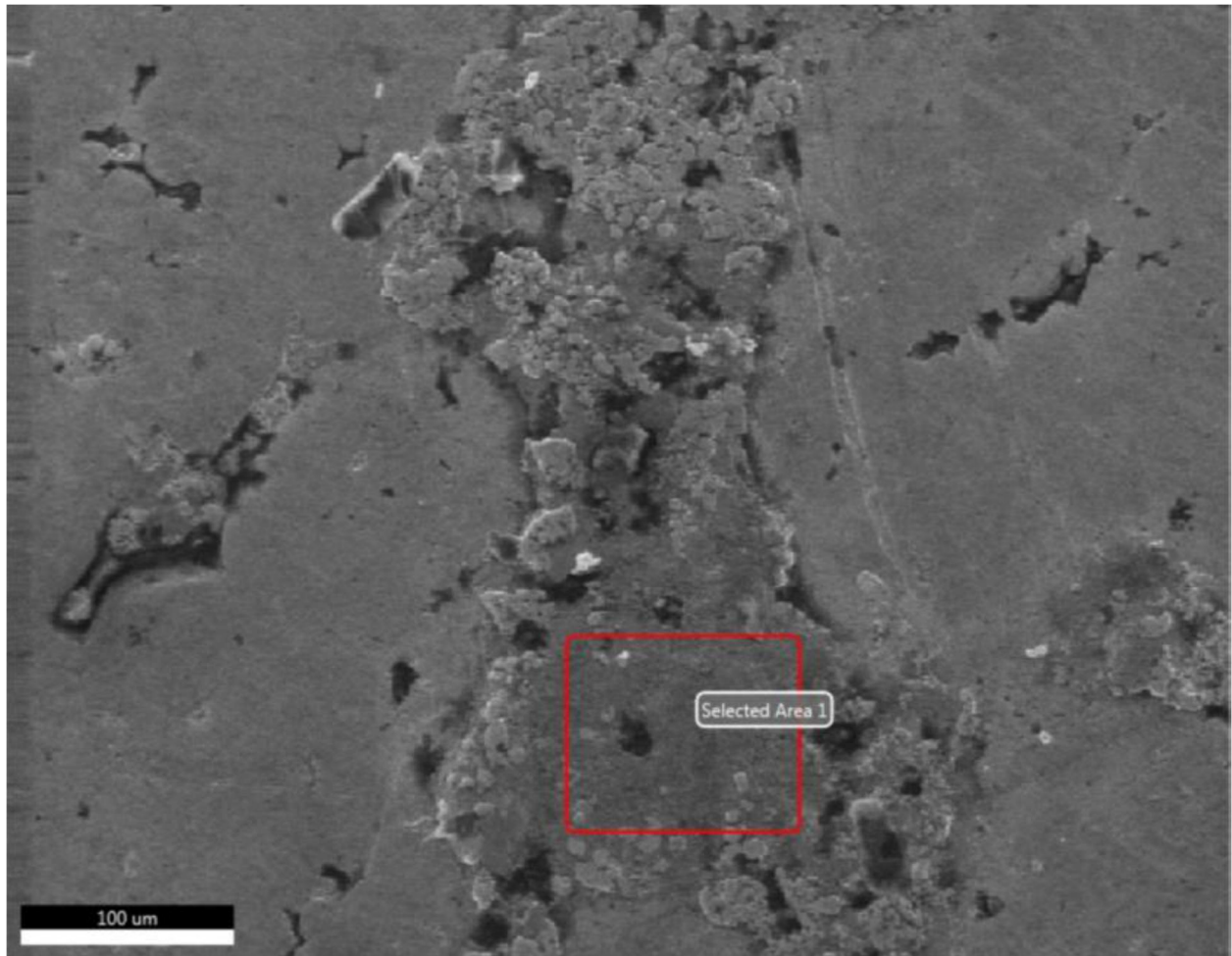


Figure 5: The black area micrograph of a typical black area between G of GRATIA and the nose area of the portrait of Ferdinand VII. Scale at lower left = 100um.



Figure 6: Obverse of the 1821 Zacatecas coin analyzed showing its non-homogenous surfaces and interpreted by PCGS as being improperly cleaned.



Figure 7: Reverse of the 1821 Zacatecas coin analyzed showing its non-homogenous surfaces and interpreted by PCGS as being improperly cleaned.

Conclusion

The results in no way show this coin's surface was improperly cleaned. The surface viewed under a stereo microscope under 20-40X showed little or no more surface marks than typical circulation marks for an AU or UNC specimen suggesting at no time was it brushed or whizzed to *any* degree. The coin exhibits full cartwheel surfaces and original toning. The non-homogenous surfaces specifically the black areas of the coin have shown it to be high copper/silver sulfide deposits with copper yielding higher

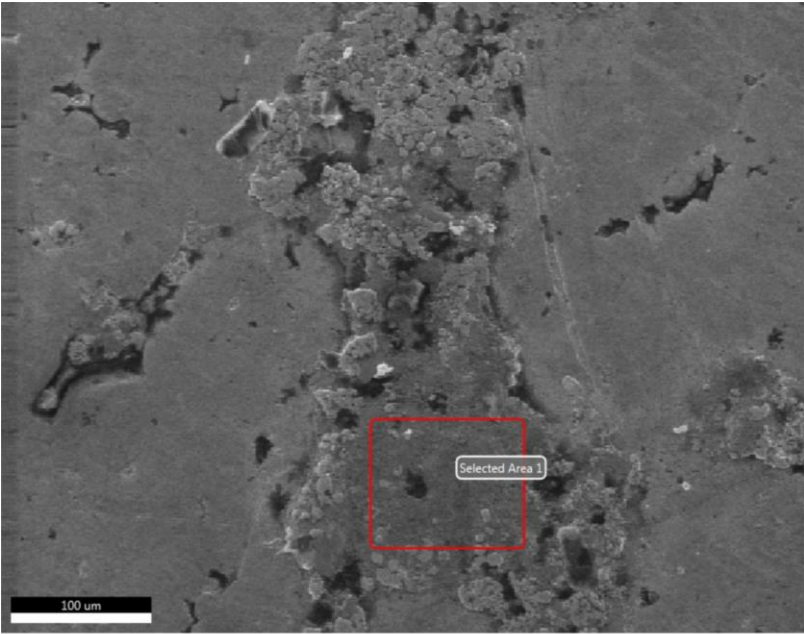
quantitative levels than silver. These high copper deposits may have been contributed by both a large addition of copper (Reaction 2 above) as a reducing agent to drive the silver halide (AgCl) ore to free silver to aid in the mercury amalgamation process either due to a lack of both iron and mercury inventory levels in these troubled times of 1821. Additionally, basic oxidation of the coin surface may have drawn up these copper deposits to the surface. Additionally, the coin's alloy has high levels of sulfur which in the opinion of the author has probably come from the Ag₂S ores that may not have been properly treated in a furnace with charcoal and salt (NaCl) prior to being mixed with the silver halide (AgCl) ores or this step may have been bypassed entirely? This combination of copper and silver sulfur compounds both in combination with each other has *clearly* produced these darkened areas giving its non-homogenous surface appearance. The author has seen other Mexican coin specimens with these noticeable dark patches similar to this piece so in some ways this is a warning to TPG services such as ANACS, PCGS and NGC to maybe consider dark alloy patching on Mexican coins or their non-homogenous appearance may be improper mercury amalgamation, poor ore mixing of silver sulfide and silver halide ores, poor furnace treatments of sulfur ores and/or surface oxidation effects over a century or more producing these non-homogenous surface coins.

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Author: Apex User
Creation: 10/4/2019 10:51:00 AM
Sample Name: Coin

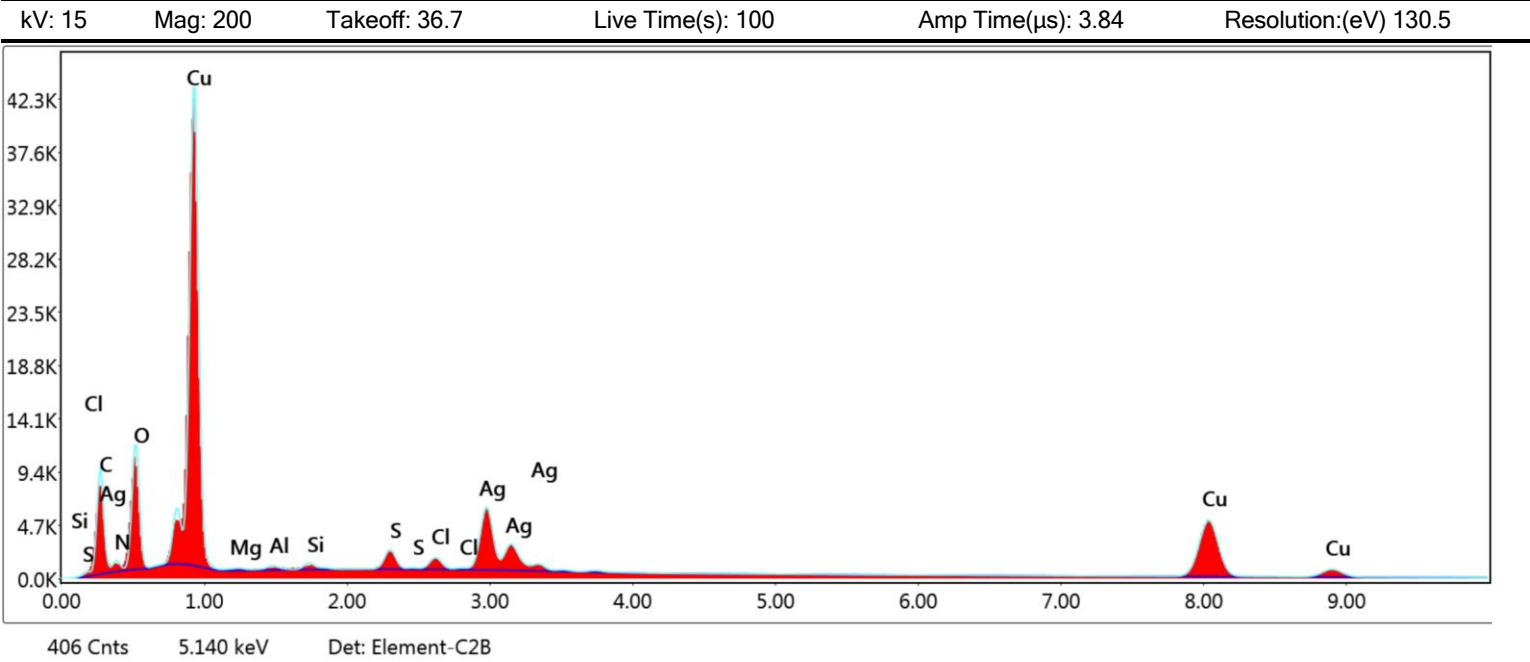
Black area between G of GRATIA and the nose



Smart Quant Results

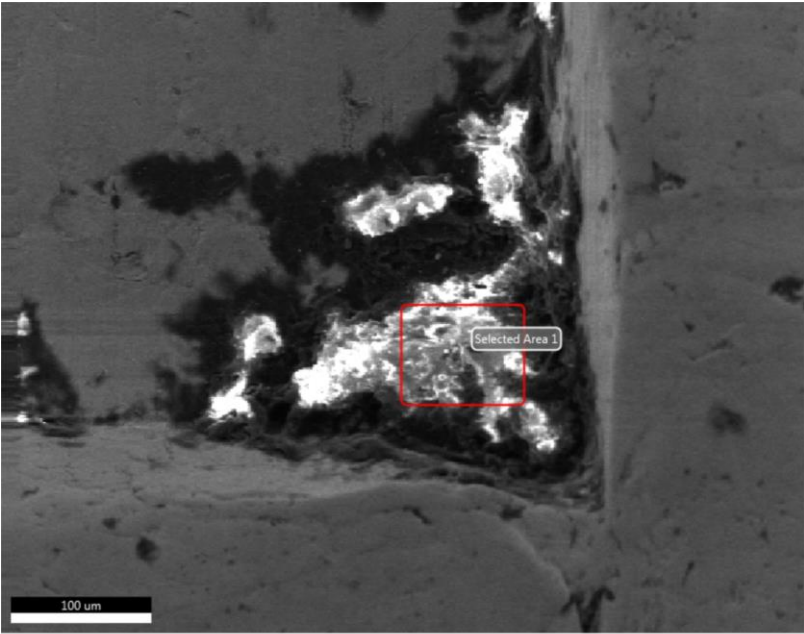
Element	Weight %	Atomic %	Error %
C K	14.87	38.67	9.19
N K	1.44	3.21	12.58
O K	12.32	24.06	8.86
MgK	0.09	0.12	72.17
AlK	0.32	0.37	16.31
SiK	0.42	0.47	13.19
S K	1.55	1.51	6.37
ClK	0.85	0.75	9.21
AgL	13.08	3.79	2.69
CuK	55.05	27.06	3.41

Selected Area 1



Author: Apex User
Creation: 10/4/2019 11:26:03 AM
Sample Name: Coin

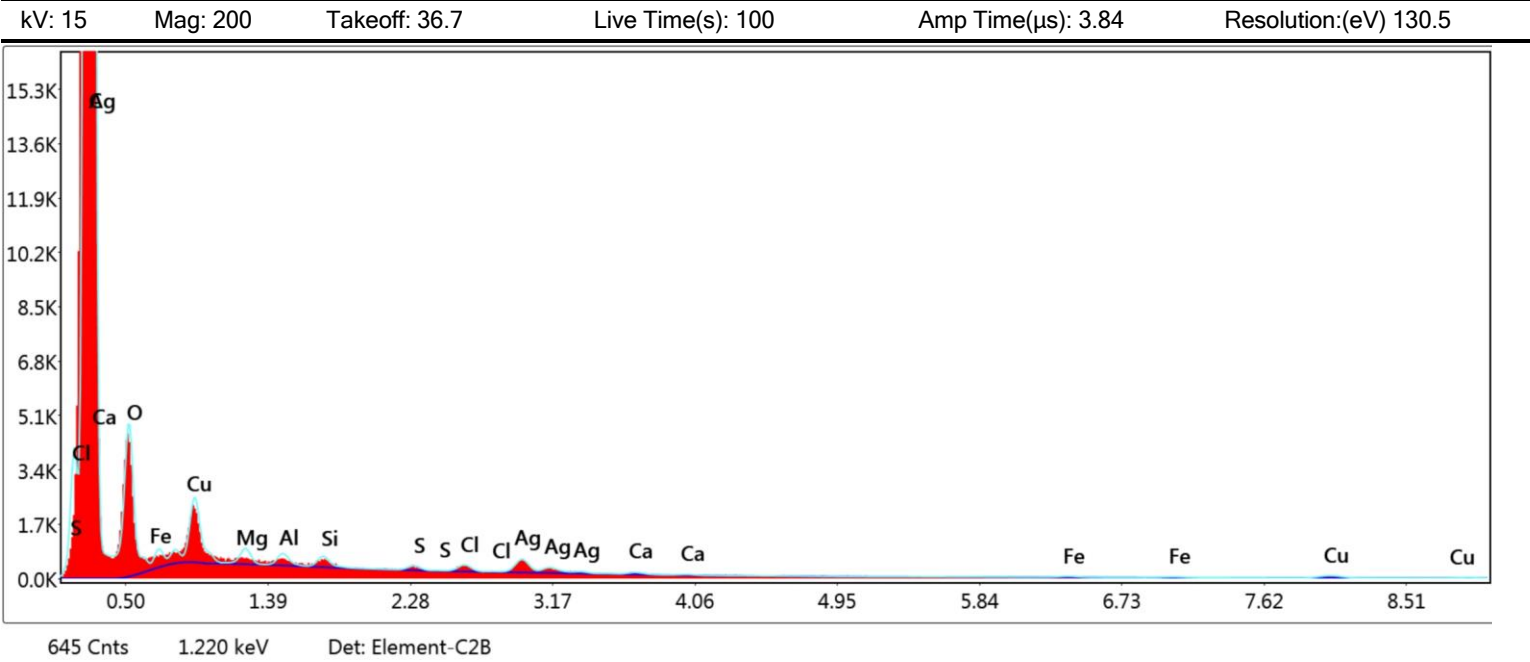
Semi-transparent material at H of HISPAN



Smart Quant Results

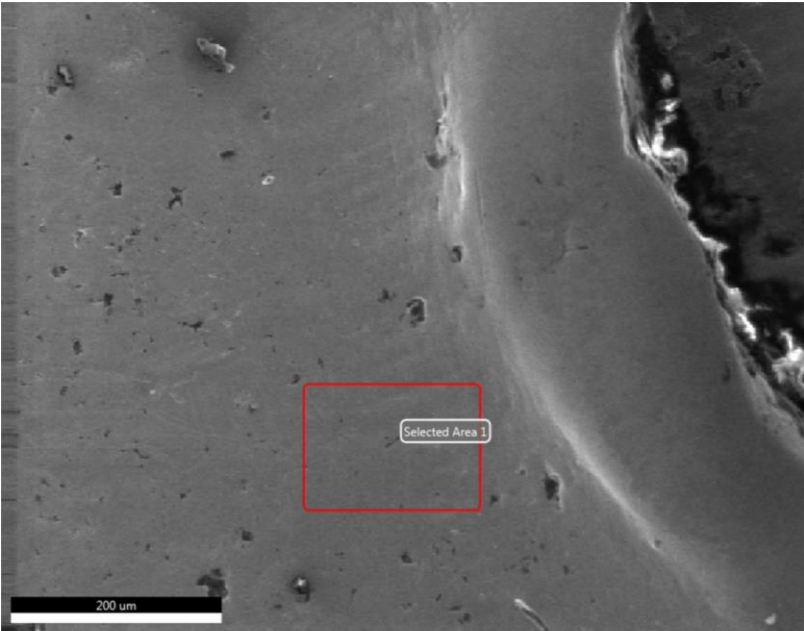
Element	Weight %	Atomic %	Error %
C K	87.19	91.58	3.2
O K	9.63	7.59	13.32
MgK	0.3	0.16	9.09
AlK	0.22	0.1	8.54
SiK	0.2	0.09	9.47
S K	0.12	0.05	15.4
ClK	0.2	0.07	11.68
AgL	1.06	0.12	9.08
CaK	0.11	0.04	32.29
FeK	0.16	0.04	30.74
CuK	0.81	0.16	14.99

Selected Area 1



Author: Apex User
Creation: 10/4/2019 10:59:25 AM
Sample Name: Coin

Silver area below GR of GRTIA



Smart Quant Results

Element	Weight %	Atomic %	Error %
37452 Coin Silver area below GR of GRTIA Selected Area 1			
C K	5.52	28.55	6
O K	3.39	13.16	12.09
MgK	0.72	1.83	12.27
AlK	0.68	1.56	10.29
SiK	0.67	1.49	8.54
S K	0.3	0.59	12.23
AgL	84.26	48.48	1.73
CuK	4.44	4.34	8.74

Spectrum Overlay

